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New Twist Added to the Role of Culture in Human Evolution

A radical new take on human evolution adds a large dose of luck to the usual story emphasizing the importance of our forebears' ability to make tools

Aug 19, 2014 | By Ian Tattersall |

We humans are very peculiar primates. We walk upright, precariously balancing our heavy bodies on two short feet. Our heads are oddly swollen, with tiny faces and small jaws tucked below the front of our balloonlike braincases. Perhaps most remarkably, we process information about the world around us in an entirely unprecedented way. As far as anyone can tell, we are the only organisms that mentally deconstruct our surroundings and our internal experiences into a vocabulary of abstract symbols that we juggle in our minds to produce new versions of reality: we can envision what *might* be, as well as describe what is.

Christian Northeast

Our predecessors were not so exceptional. The fossil record clearly shows that not much more than seven million years ago, our ancient precursor was an apelike, basically tree-dwelling creature that carried its weight on four limbs and had a large projecting face and powerful jaws hafted in front of a very modest-sized braincase. In all probability, it possessed a cognitive style broadly equivalent to that of a modern chimpanzee. Though undeniably smart, resourceful, and able to recognize and even combine symbols, modern apes do not seem capable of rearranging them to forge new realities. Thus, to arrive at our own species, *Homo sapiens*, from this ancestor took a lot of fast evolutionary modification.

Seven million years may seem like a long time, but it is quick for this kind of transformation. To grasp just how swift the change was, consider that closely related primate species—certainly those in the same genus—typically do not display very different physical or cognitive traits. Moreover, scientists estimate the average

longevity of a mammal species at around three million to four million years—about half the time in which the entire hominin group (which includes us and our extinct humanlike relatives) has existed and changed beyond recognition. If evolutionary histories consist of ancestral species giving rise to descendant ones, as we know they do, then the rate of speciation, or introduction of new species, must have sped up dramatically in the human line to account for the radical alterations observed.

Why has evolution in our family been unusually rapid? By what mechanism did this acceleration take place? These are obvious questions and yet, oddly enough, not ones that have greatly interested fossil-oriented students of human evolution. Almost certainly the answer involves our ancestors' ability to meet challenges by producing stone tools, clothing, shelter, fire, and so forth—objects referred to as material culture because they reflect how their users lived. Scientists have long held that natural selection favored those early humans who were best able to innovate and share their cultural know-how. More capable individuals survived and reproduced the most, leading to steady advancements among hominins as a whole.

But this sort of refinement, one generation at a time, would not have been fast enough to radically reshape the human line in seven million years. As we learn more about climate shifts during the past two million years, a new picture is emerging, in which dramatic climate fluctuations acted in tandem with material culture to quicken the evolutionary pace among our forebears. It seems likely that tools and other technologies allowed early hominins to launch themselves into new environments, although when conditions periodically deteriorated, those aids could no longer guarantee survival. As a result, many populations splintered, allowing genetic and cultural novelties to take root much faster than could have happened in larger groups, leading to rapid evolution. Others simply perished. And the species that ultimately prevailed—us—owed its victory as much to chance occurrences, such as those climate shifts, as to its talents.

A Shift toward the Ground

Despite the hugely important role material culture has played in generating the rather extraordinary phenomenon that is *H. sapiens* today, it made a relatively late appearance in our evolutionary story. More than four million years before our ancestors learned to use tools, they first had to quit an existence in the trees and begin to test life on the ground, no small feat for an ape with four grasping extremities. The move would have required an ape that was already in the habit of holding its trunk upright—suspending its considerable body weight from its arms as much as supporting it with its legs. And indeed, this posture is known to have occurred among some early hominoids—members of the superfamily to which the apes and hominins belong.

Abandoning the trees lies at the origin of our vastly altered anatomy and undeniably set the stage for later adaptations in our lineage, but it did not step up the evolutionary tempo of events. For five million years or so after hominins emerged, they evolved very much like any successful primate group: from the beginning, the human family tree was bushy—meaning there were numerous species occurring at any one time, all testing the new potential that walking on two feet offered. This early experimentation was evidently not of the transformative kind; during this period, all hominins seem to have been variations on the same basic themes, in terms of where and how they lived. As befitted creatures whose lives were distributed between the trees and more open habitats, these ancient human ancestors remained modest in brain and body size and retained archaic body proportions, with short legs and highly mobile arms.

The rate of evolution began to increase dramatically only after the entrance of our genus *Homo* about two million years ago. By at least half a million years before our debut, though, material culture had been born in the form of stone tools, lending strong support to the idea that culture helped to fuel our rapid transformation from a steady succession of tree-dwelling apes to a fast-changing lineup of ground-dwelling humans. Scientists have found primitive stone tools in Africa dating to 2.6 million years ago, and evidence of tool marks on animal bones dates from even earlier. Hominins of the old kind almost certainly made these simple utensils, small, sharp flakes knocked off fist-sized stone cores.

Despite their archaic anatomy, the early toolmakers had moved well beyond the ape cognitive range. Even with intensive coaching, modern apes find it impossible to grasp how to hit one lump of stone with another to detach a flake in the deliberate way used by early hominins. One purpose of such flakes was butchering the carcasses of grazing mammals. This radically new behavior implies that hominin diets had broadened rapidly, from being primarily vegetarian to relying more on animal fats and proteins—though whether by scavenging or by active hunting at this stage is unknown. This richer diet underwrote the later rapid expansion of the energy-hungry brain among members of *Homo*.

Biologists hotly debate over which fossils represent the earliest incarnation of *Homo*, but they agree that the first hominins to possess body proportions basically equivalent to our own appeared less than two million years ago. At about the same time, hominins made their way to many parts of the Old World from Africa. These individuals walked like we do, with an upright, striding gait, lived in the open savanna away from the shelter of the forest and almost certainly ate a diet rich in animal resources. The earliest *Homo* had brains only somewhat larger than those of the early bipeds, but by a million years ago *Homo* species bore brains that had doubled in size, and by 200,000 years ago they had almost doubled again.

Ice Age Arms Race?

This rate of brain gain is amazing by anybody's reckoning and has been identified in at least three independent lineages within *Homo*—namely the one leading to *Homo neanderthalensis* in Europe, to late *Homo erectus* in eastern Asia, and to our own *H. sapiens* in Africa. These parallel trends indicate both that a large brain gave the species involved a survival advantage and that brain enlargement was a common propensity of the genus and not just of the direct lineage to *H. sapiens*. Just conceivably, the tendency hints at an arms race of sorts, as the adoption of projectile weapons made human groups one another's most dangerous predators even as they competed economically for resources.

The traditional explanation of rapid brain development in hominins, favored by evolutionary psychologists, is known as gene-culture coevolution. This process involves the steady operation of natural selection on successive generations of individuals, with powerful positive feedback between innovation in the biological and cultural spheres. As bigger-brained individuals thrived across successive generations, the population became smarter; in turn, it produced tools and other innovations that helped it adapt even more successfully to its environment. In this model, the inherent interplay between genes and culture within a single gradually transforming lineage of species would have virtually obliged human predecessors to become more intelligent and behaviorally complex and would have predisposed them to faster evolutionary change.

A little thought, however, suggests that there must have been more to it than that. One problem with this scenario is that it assumes that the pressures of natural selection—stresses to which the species were adapting—remained consistent over long periods. But in fact, *Homo* evolved during a period of Ice Ages, when the ice caps periodically advanced to what is now New York City and northern England in the Northern Hemisphere, and the tropical zone experienced periods of extreme aridity. Amid such environmental instabilities, no consistent directional selection pressures could have existed. The more we learn about these climatic oscillations, the more we realize just how unstable the ancient environments of our ancestors must have been. Cores drilled in the ice caps and in seafloor muds reveal that the swings between warmer and dramatically colder conditions became increasingly pronounced after about 1.4 million years ago. The result was that in any one location, resident hominin populations would have needed to react frequently to abruptly changing conditions.

Another problem with the standard explanation has to do with the material record itself. Instead of showing a pattern of steadily increasing technological complexity over the past two million years, archaeological finds suggest that innovation appeared highly sporadically. New types of implements, for example, were typically introduced only at intervals of hundreds of thousands or even a million years, with minimal refinement in between. Hominins at this stage seem to have reacted to environmental change by adapting old tools to new uses, rather than by inventing new kinds of tools.

Adding doubt to the notion of gradual evolution is a lack of evidence that hominin cognitive processes were continuously refined over

time. Even as larger-brained species of *Homo* made their appearance, older technologies and ways of life persisted; newer ways of doing things typically came about intermittently and not with the introduction of new species but during the tenure of existing ones. Most notably, evidence of distinctively modern symbolic cognition emerged rather suddenly and only very late indeed. The earliest overtly symbolic objects—two smoothed ocher plaques with geometric engraving—show up at Blombos Cave in South Africa about 77,000 years ago, significantly after anatomically recognizable *H. sapiens* had entered the scene (some 200,000 years ago). Because the patterns involved are highly regular, researchers feel confident that they are not random but encode information. Such sudden breakthroughs are not the mark of steady intellectual advancement, generation by generation.

Small Population Potential

Evidently, then, we have to look away from processes occurring within individual lineages to explain the rapid change among Ice Age hominins. Yet the same elements implicated in the gene-culture coevolution story—environmental pressures and material culture—may still have been in play. They simply operated rather differently from how the traditional portrayal suggests. To understand how these factors may have interacted to trigger evolutionary change, we must first recognize that a population needs to be small if it is to incorporate any substantial innovation, genetic or cultural. Large, dense populations simply have too much genetic inertia to be nudged consistently in any direction. Small, isolated populations, on the other hand, routinely differentiate.

Today the human population is sedentary, enormous and continuously distributed across all habitable areas of the globe. But in Ice Age times hominins were mobile hunters and gatherers, living off nature's bounty and thinly spread across the Old World. Climate change constantly buffeted these tiny local populations. Temperature and humidity swings, and even fluctuating sea and lake levels, severely affected local resource availability, altering the vegetation and driving animals elsewhere. Localities often became hostile to hominins, or even uninhabitable, before kinder conditions returned.

By between one million and 500,000 years ago hominins had a range of technologies—from toolmaking to cooking to shelter building—that would have allowed them to exploit the environment more efficiently than earlier species and to transcend purely physiological limitations. These technologies would presumably have permitted Ice Age hominins to substantially broaden the environments they occupied. In good times, technology would have enabled hominin populations to expand and to occupy marginal regions that would otherwise have been unavailable to them. But when climatic conditions deteriorated, as they periodically did, culture would have proved an incomplete buffer against the harsh elements. As a result, many populations would have declined in size and become fragmented.

The resulting small, isolated groups would have presented ideal conditions for both the fixation of genetic and cultural novelties and ensuing speciation. When conditions improved once more, the altered populations would have expanded again and come into contact with others. If speciation had taken place, competition and selective elimination would have likely occurred. If speciation was incomplete or absent, any genetic novelties would have been incorporated into merged populations. Either way, change took place. In the unsettled Ice Age conditions, this process would have repeated many times in quick succession, setting the scene for exceptionally fast evolution, ultimately leveraged by the possession of material culture. When the dust settled, we stood alone, the serendipitous beneficiaries of cognitive advances, cultural innovation and climate changes that allowed us to eliminate or outlast all hominin competition throughout the Old World in an astonishingly short time. Our competitive edge was almost certainly conferred by our acquisition of our unique mode of symbolic thought, which allows us to scheme and plan in unprecedented ways. Interestingly, this development seems to have occurred within the tenure of our species *H. sapiens*, evidently spurred by a cultural stimulus, quite plausibly the invention of language, which is the ultimate symbolic activity.

This perspective on our evolution, in which our admittedly remarkable species emerged from a rapid sequence of random external events entirely unrelated to our ancestors' specific qualities, is substantially less exalting than the traditional idea of stately improvement over the eons. But a close look at the product makes this entirely plausible: it does not take much introspection to realize that, for all its impressive qualities, *H. sapiens* is a hugely unperfected species—a subject on which volumes have already been written, not least by evolutionary psychologists.

Seeing our amazing species as an evolutionary accident, though, contains a profound lesson. For if we were not shaped by evolution to be something specific—fitted to our environment and tailored to a purpose—then we have free will in a way that other species do not. We can indeed make choices about the ways in which we behave. And this means, of course, that we must accept responsibility for those choices.

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